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Developing a Taxonomy for Mission Architecture Definition

Final Report

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Prepared By: Deborah J. Neubek

Academic Rank: Visiting Assistant Professor

University & Department: University of Houston
College of Architecture
Houston, TX 77204-4431

NASA/JSC

Directorate: Lunar & Mars Exploration
Program Office

Division: System Engineering & Integration

JSC Colleague: Norman H. Chaffee

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Abstract

The Lunar & Mars Exploration Program Office (LMEPO) was tasked to define candidate architectures for the Space Exploration Initiative to submit to NASA senior management and an externally constituted Outreach Synthesis Group. A systematic, structured process for developing, characterizing and describing the alternate mission architectures, and applying this process to future studies was developed. The work was done in two phases: first, National Needs were identified and categorized into objectives achievable by the Space Exploration Initiative. Secondly, a Program Development Process was created which both hierarchically and iteratively describes the program planning process.

Introduction

The Space Exploration Initiative (SEI) is the program being developed in response to President George Bush's proposal to take the U.S. back to the Moon then on to Mars. Whereas in 1961 it took a crisis (the space race) to galvanize the nation to reach for the stars, SEI is based on the President's belief that space holds an opportunity for greatness.

After the initial speech given by the President on July 20, 1989, NASA undertook a 90-Day Study which resulted in a potential approach to achieving these goals. The National Space Council then decided to broaden the input to this activity and requested that an independent committee synthesize data collected from an unrestricted range of public and private institutions and individuals (Outreach). This committee, termed the Synthesis Group and chaired by General Thomas Stafford, is due to produce a report in March, 1991 which suggests "at least two" alternatives for embarking on the Space Exploration Initiative.

Determining Program Objectives from National Needs

To fully reap the benefits of SEI, it is important to identify the National Needs which can be met by the program and a process by

which links may be forged. Linking National Needs to program planning results in two separate but related products:

- Program drivers (key goals and objectives to be achieved) which are INPUTS to the program planning process.
- Program benefits which are OUTPUTS from doing the program and are what the American public wants to receive from their investment.

It was in this context that a team of Level I and Level II people performed an analysis of national needs and policies which resulted in the chart seen in figure 1. This chart lists National Needs in terms of achievable goals and objectives which might guide program planning. The group identified seven primary areas of National Needs which may be addressed by the SEI. These are to: Invigorate National Spirit and Pride; Expand Human Knowledge; Stimulate Education; Strengthen the Economy; Improve the Quality of Life; Improve International Relations; and Strengthen National Security.

Under each of these areas, specific objectives were identified which might be set by a policymaker as an area of emphasis. For example, if "Enhance and improve potential career opportunities" were designated as a high priority objective, the SEI architecture developed might show additional coop programs included in the management plan.

It is important to note that the SEI program will meet all the objectives listed to some extent. However, the set of objectives selected as program drivers will influence the final implementation of the program. An alternate set of objectives would yield a program which is different in its make-up. Therefore, different architectures may be created which all meet the basic National Needs, however, architecture "A" may have enhanced commercialization programs whereas architecture "B" might place more of an emphasis on scientific research.

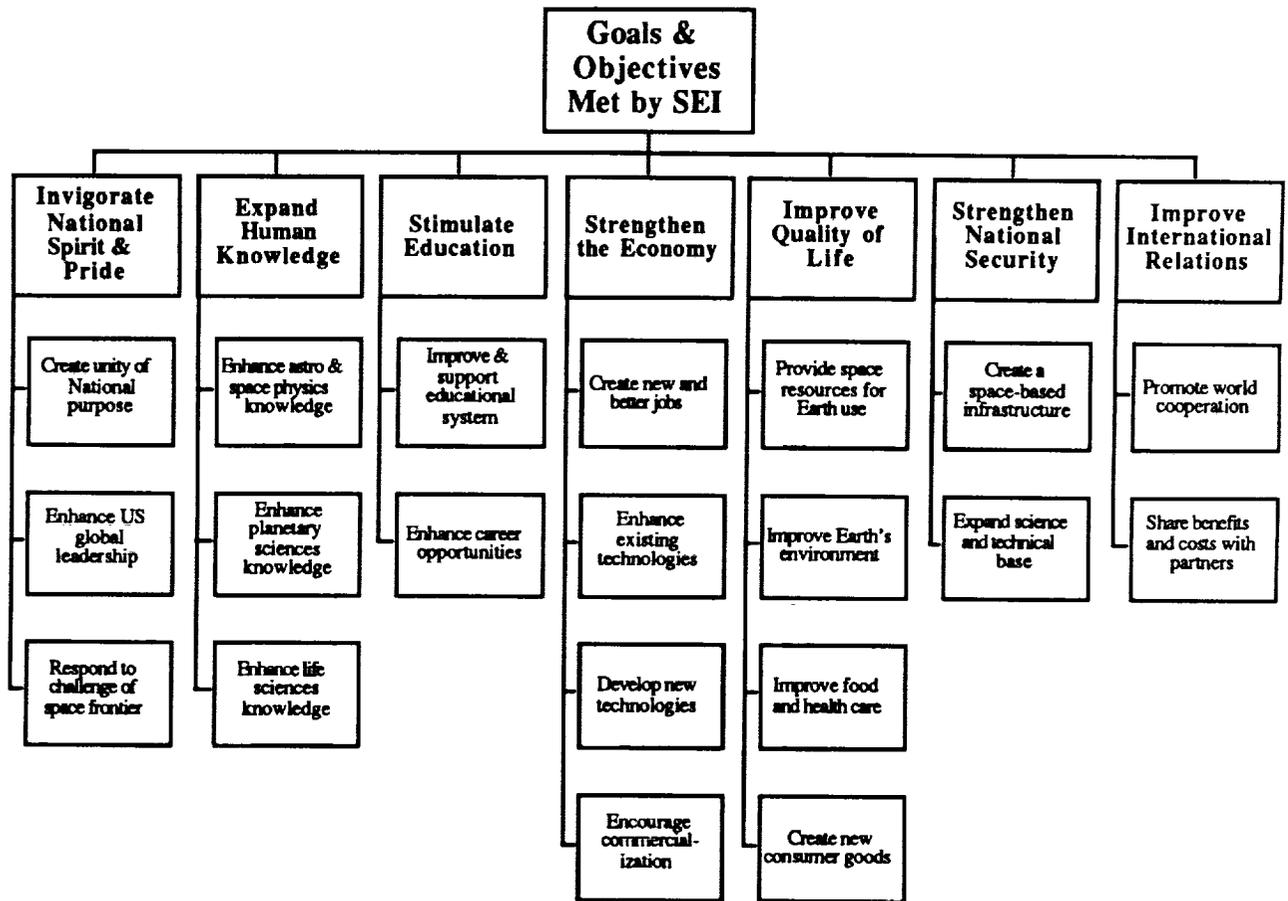


Figure 1: National Needs Stated as Policy Objectives

Developing a Process to Link National Needs to Implementations

Once the National Needs were identified, it was necessary to develop a process by which they could be physically linked to specific program goals and features. In the most basic of terms, three questions must be answered to develop a program: Why go? What will we do? How will we do it? The chart in figure 2 illustrates a top-down, hierarchical approach for linking National Needs to program implementation. This chart serves as a logical outline which shows the different levels of definition needed to complete the description of a program architecture.

Developing a program as complex as the SEI is not strictly hierarchical, however. It is an iterative process with many inter-related steps. Figure 3 illustrates the primary steps and their relationships.

The first step in developing a program is to define the **program purpose** by determining the primary drivers: Why are we going? What do we want to accomplish?

These questions may be answered through:

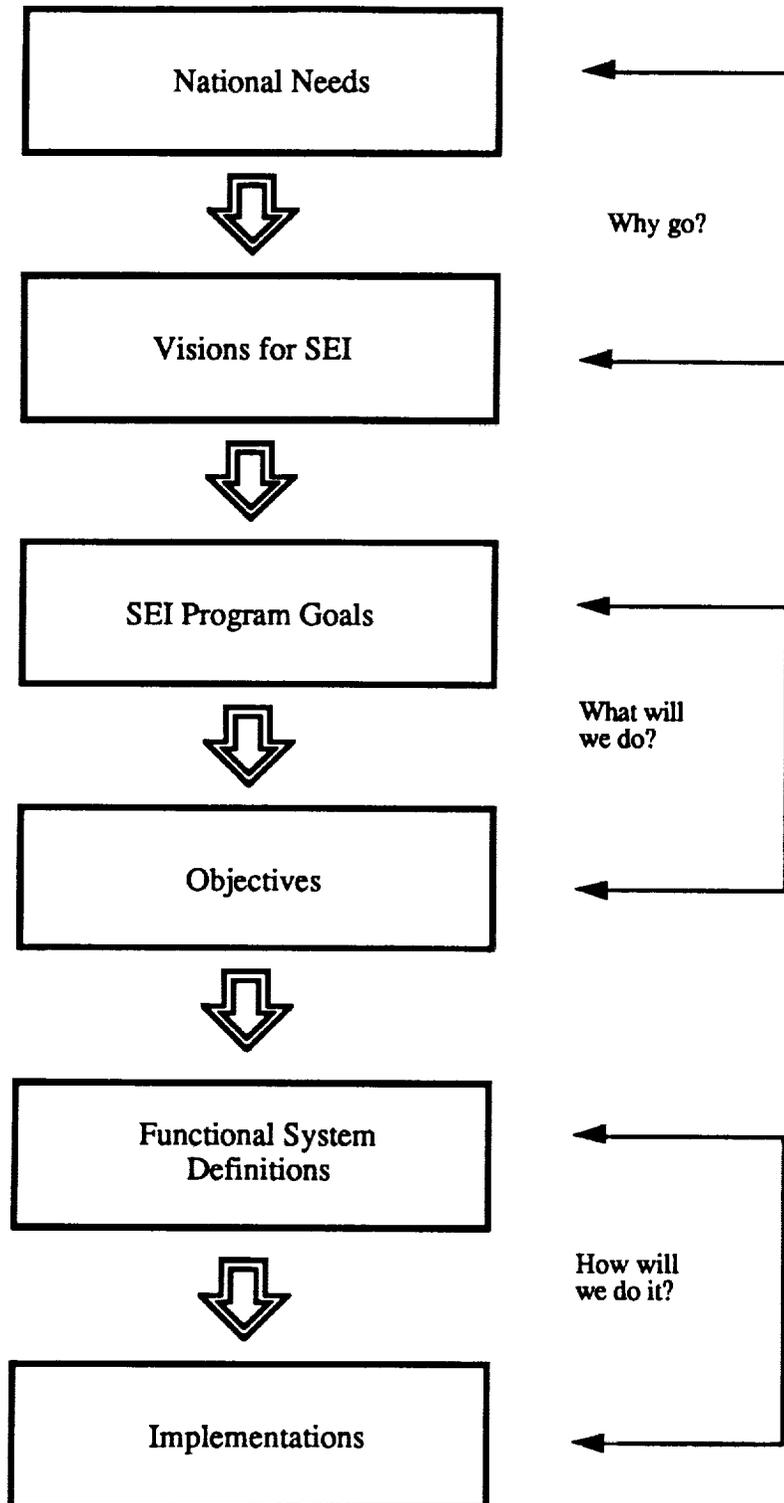
- understanding the overarching National Needs
- establishing Visions which will guide SEI planning and respond to National Needs
- setting Program Goals which define what must be achieved to fulfill the Visions and
- creating a Program Mission Statement which captures the essence of the SEI Program Goals.

Each of these areas may be defined as follows:

National Needs are the same as those discussed previously and shown in figure 1.

Six Visions have been enumerated by the Synthesis Group to guide SEI planning. These are:

- Enhance knowledge of the planets including Earth
- Rejuvenate interest in science and technology



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Figure 2: Linking National Needs to Implementations

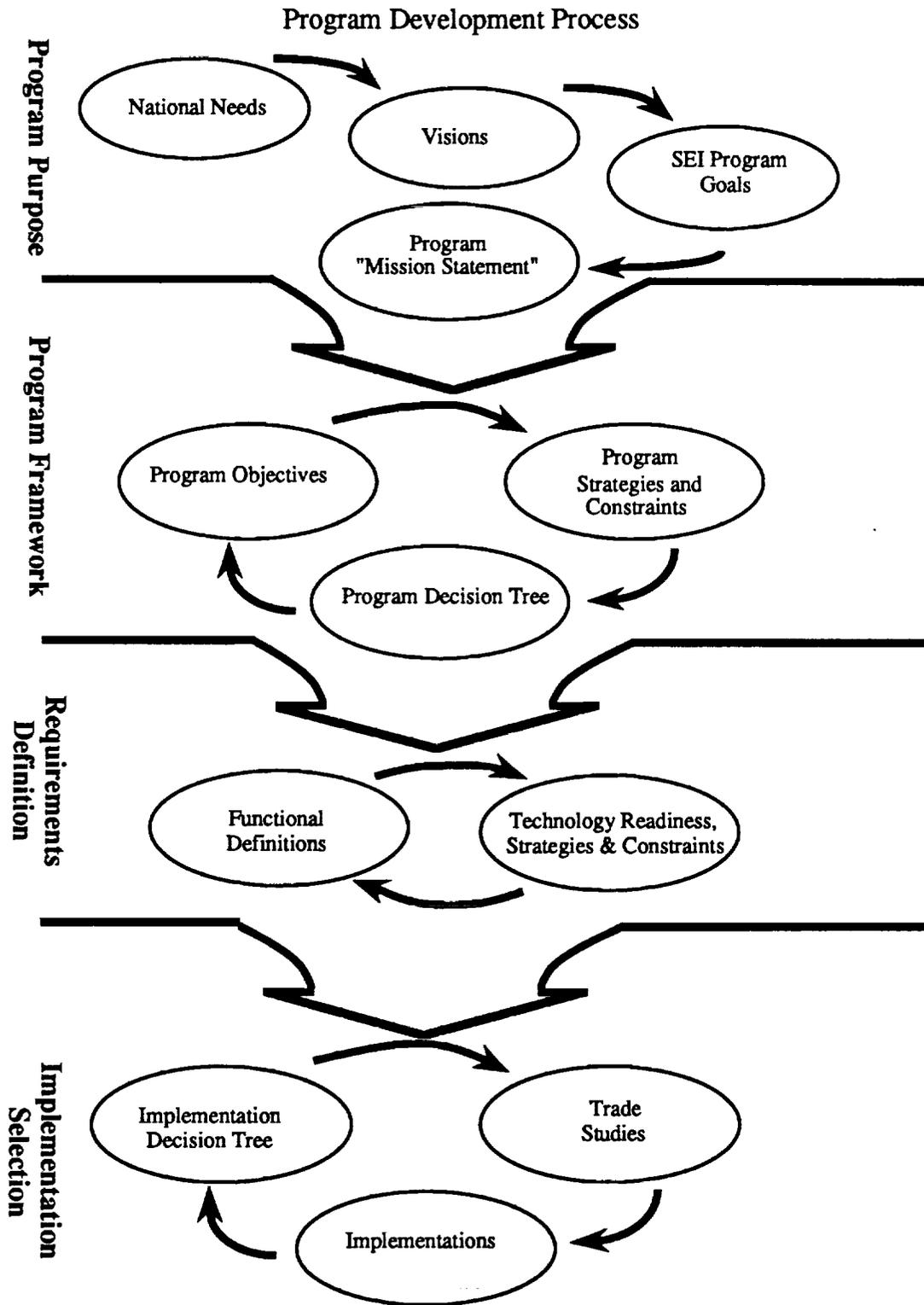


Figure 3: An Iterative Program Development Process

- Refocus the role of U.S. world leadership
- Develop technologies with terrestrial applications
- Facilitate further space exploration and privatization
- Boost the U.S. economy

SEI Program Goals are specific, space-oriented statements which guide and direct the program so the visions are fulfilled. They serve as the "missing link" between "fuzzy" national needs and "hard" technical or programmatic requirements.

A "universal set" of goals, including some which may be incompatible with others may be created. A subset of these goals which are internally consistent may then be selected to create an architectural theme. For clarity it is useful to break these goals into two categories:

- spacefaring ("of or engaged in life in Space"— Webster's)
- administrative ("of or related to policies, procedures or management issues")

The SEI Program Mission Statement captures the essence of the primary drivers for a given program theme. It is made up of a selected subset of SEI Program Goals.

Once the program purpose is established, a **program framework** must be laid out to provide the foundation for requirements definition. This consists of iteratively identifying program objectives, strategies, constraints and key decisions. Program Objectives are those measurable program features which serve to frame what should be done, specifically, to fulfill the program goals. Program Strategies are the internal, long range approaches which cut across systems. They are methods or plans of action for accomplishing the objectives. Program Constraints are those external limitations, guidelines or policies which are imposed upon the program. These may be technical, budgetary or programmatic in nature. Key Decisions are those decision points identified by examining each of the previously selected elements of the Program Purpose and Program Framework and incorporating temporal considerations. A key point in creating the Program Framework is to assure that these decisions are top-level in nature, and deal with programmatic issues.

The next step is to begin **requirements definition**. Systems must be defined in terms of their functional parameters while technology readiness, strategies and constraints must be identified. The Functional Definitions are descriptions which are expressed in terms of capabilities and are grouped into like areas. For example, planetary surface operations is a functional area. Early program decisions may be made through the examination of Technology Readiness, Strategies and Constraints. Once the critical technologies are identified, they can be plotted on a temporal scale and interrelationships drawn. This leads to the creation of a tool which aids in determining which programs have the greatest impact on others, as well as which programs should be started early on in the overall SEI schedule.

Finally **implementation** trade spaces may be selected and studied, leading to decisions for future technology and advanced development programs.

Conclusions

The Program Development Process is a tool by which the SEI program may be planned hierarchically, beginning with National Needs and working down to implementations. A key factor in using it successfully is to identify the appropriate levels of detail and depth which should be addressed at each step. In general, the program should be planned from the top down, defining what should be done, then functionally how it should be done. Only after this has been accomplished can the implementation studies be optimized.

This process is iterative, and not only entails interrelating components at each step, but also assumes the entire process will be repeated as new information is returned from studies. By developing a program for the SEI that is guided by National Needs, SEI can be optimized for returning the greatest benefits possible to the nation.

